CLAIMS

We claim:

1. An apparatus for sensing ground moisture and producing a variable electrical capacitance indicative of ground moisture, comprising:

a shell which is water permeable and restrictive against influx of dirt therethrough, said shell defining an internal surface which defines an internal cavity therein;

granular fill material within the internal cavity of the shell and against substantial portions of the internal surface to conduct moisture therefrom;

first and second electrodes arranged within the internal cavity in proximity to the granular fill material, said first and second electrodes having dielectric coverings thereon to prevent conduction of electrical current between the electrodes and the granular fill material.

2. An apparatus according to claim 1 wherein said first and second electrodes are arranged in an approximately parallel relationship within said internal cavity.

3. An apparatus according to claim 1 wherein said first and second electrodes are lineal electrodes arranged in an approximately parallel relationship within said internal cavity.

4. An apparatus according to claim 1 wherein said first and second electrodes are lineal electrodes arranged in an approximately parallel relationship which extends along a convoluted path within said internal cavity.

5. An apparatus according to claim 1 wherein said first and second electrodes are lineal electrodes arranged in an approximately parallel relationship which extends along an approximately helical path within said internal cavity.

6. An apparatus according to claim 1 wherein said first and second electrodes are arranged in an approximately parallel and helical arrangement within said internal cavity.

7. An apparatus according to claim 1 wherein said granular fill material is made from granules which are predominantly larger than about 0.01 inches in diameter.

8. An apparatus according to claim 1 wherein said granular fill material is made from granules which are predominantly larger than about 0.01 inches and predominantly less than about 0.1 inches in diameter.

9. An apparatus according to claim 1 wherein said granular fill material is made from granules which are predominantly larger than about 0.01 inches and predominantly less than about 0.1 inches in diameter.

10. An apparatus for sensing ground moisture and producing a variable electrical capacitance indicative of ground moisture, comprising:

a shell which is water permeable and restrictive against influx of dirt therethrough, said shell defining an internal surface which defines an internal cavity therein;

granular fill material within the internal cavity of the shell and against substantial portions of the internal surface to conduct moisture therefrom;

at least one electrode support positioned within the internal cavity to provide support to the first and second electrodes;

first and second electrodes supported by said at least one electrode support and arranged within the internal cavity in proximity to the granular fill material, said first and second electrodes having dielectric coverings thereon to prevent conduction of electrical current between the electrodes and the granular fill material.

11. An apparatus according to claim 10 wherein said at least one electrode support is made from a water resistant material.

12. An apparatus according to claim 10 wherein said first and second electrodes are arranged in an approximately parallel relationship in an arrangement trained about the at least one electrode support.

13. An apparatus according to claim 10 wherein said first and second electrodes are linear electrodes arranged in an approximately parallel relationship in an arrangement trained about the at least one electrode support.

14. An apparatus according to claim 10 wherein said first and second electrodes are linear electrodes arranged in an approximately parallel relationship in an arrangement trained about the at least one electrode support to form a convoluted electrode route.

15. An apparatus according to claim 10 wherein said first and second electrodes are linear electrodes arranged in an approximately parallel relationship in an arrangement trained about the at least one electrode support to form a helical electrode route.

16. An apparatus according to claim 10 wherein said first and second electrodes are linear electrodes arranged in an approximately parallel relationship in an arrangement trained about the at least one electrode support to form a helical electrode route having approximately equal helical advance pitch between adjacent turns of the helical arrangement.

17. An apparatus according to claim 10 wherein said granular fill material is made from granules which are predominantly larger than about 0.01 inches in diameter.

18. An apparatus according to claim 10 wherein said granular fill material is made from granules which are predominantly larger than about 0.01 inches and predominantly less than about 0.1 inches in diameter.

19. An apparatus according to claim 10 wherein said granular fill material is made from granules which are predominantly larger than about 0.02 inches and predominantly less than about 0.05 inches in diameter.

20. An apparatus for sensing ground moisture and producing a variable electrical capacitance indicative of ground moisture, comprising:

a shell which is water permeable and restrictive against influx of dirt therethrough, said shell defining an internal surface which defines an internal cavity therein;

granular fill material within the internal cavity of the shell and against substantial portions of the internal surface to conduct moisture therefrom, said granular fill material having from granules which are predominantly larger than about 0.01 inches in diameter;

at least one electrode support made from a moisture resistant material and positioned within the internal cavity to provide support to the first and second electrodes;

first and second electrodes supported by said at least one electrode support and arranged within the internal cavity in proximity to the granular fill material, said first and second electrodes having dielectric coverings thereon to prevent conduction of electrical current between the electrodes and the granular fill material.

21. An apparatus according to claim 20 wherein said granular fill material is made from granules which are predominantly larger than about 0.01 inches and predominantly less than about 0.1 inches in diameter.

22. An apparatus according to claim 20 wherein said granular fill material is made from granules which are predominantly larger than about 0.02 inches and predominantly less than about 0.05 inches in diameter.

23. An apparatus forming an ancillary circuit for use with a capacitive soil moisture sensor, comprising:

an oscillator for providing a voltage varying excitation signal having an oscillation frequency;

a bridge circuit coupled to the oscillator to detect variations in capacitance demonstrated by a sensor connected to the ancillary circuit, said bridge circuit having a sensor leg which defines sensor terminals to which a capacitive soil moisture sensor is connected thereto;

a rectifier coupled to the bridge circuit to rectify imbalance demonstrated by the bridge and provide a rectifier signal therefrom;

at least one filter coupled to the bridge circuit and rectifier to help smooth the rectifier signal and provide a moisture output signal therefrom.

24. An apparatus according to claim 23 wherein the oscillation frequency is in the range of about 10kHz to about 250kHz.

25. A bridge circuit in accordance with claim 23 wherein the oscillation frequency is in the range form about 80kHz to about 150kHz.

26. A bridge circuit in accordance with claim 23 further comprising a voltage regulator for regulating the voltage in close proximity to the oscillator.

27. A bridge circuit in accordance with claim 23 further comprising at least one coupling capacitor interposed between the oscillator and bridge circuit.

28. A bridge circuit in accordance with claim 23 further comprising a thermistor forming a part of the bridge circuit to provide temperature adjustment.

29. An apparatus forming an ancillary circuit for use with a capacitive soil moisture sensor, comprising:

an oscillator for providing a voltage varying excitation signal having an oscillation frequency, the oscillation frequency being in the range of about 10kHz to about 250kHz;

a voltage regulator for regulating the voltage in close proximity to the oscillator;

a bridge circuit coupled to the oscillator to detect variations in capacitance demonstrated by a sensor connected to the ancillary circuit, said bridge circuit having a sensor leg which defines sensor terminals to which a capacitive soil moisture sensor is connected thereto;

a thermistor forming a part of the bridge circuit to provide temperature adjustment;

a rectifier coupled to the bridge circuit to rectify imbalance demonstrated by the bridge and provide a rectifier signal therefrom;

at least one filter coupled to the bridge circuit and rectifier to help smooth the rectifier signal and provide a moisture output signal therefrom.

30. A bridge circuit in accordance with claim 29 further comprising at least one coupling capacitor interposed between the oscillator and bridge circuit.

31. An apparatus according to claim 29 wherein the oscillation frequency is in the range of about 10kHz to about 250kHz.

32. A bridge circuit in accordance with claim 29 wherein the oscillation frequency is in the range form about 80kHz to about 150kHz.

33. An irrigation controller comprising:

a comparator configured to be coupled to a moisture signal from an external source and coupled to a selective threshold signal, the comparator being further configured to provide a comparison signal responsive to comparing the moisture signal and the selective threshold signal;

an oscillator configured to provide a clock signal;

a counter coupled to the clock signal and configured to provide a bridge enable signal and a valve enable signal and an oscillator freeze signal;

a switch circuit configured to selectively provide electrical power to an external load responsive to the bridge enable signal; and

an optical switch circuit configured to selectively provide electrical power to another external load responsive to the valve enable signal and the comparison signal, the oscillator being further configured to halt the providing the clock signal responsive to the oscillator freeze signal.

34. An irrigation controller in accordance with claim 33 wherein the counter is further configured to provide the bridge enable signal for a first period of time and to provide the valve enable signal for a second period of time, and wherein the second period of time is contemporaneous with a later portion of the first period of time.

35. An irrigation controller in accordance with claim 33 wherein the timer is further configured to provide the oscillator freeze signal after the first period of time.

36. An irrigation controller in accordance with claim 33 wherein the irrigation controller is configured to be coupled to an external source of electrical power.

37. An irrigation controller in accordance with claim 33 and further configured to reset the counter responsive to a loss and a subsequent restoration of the electrical power from the external source.

38. An irrigation controller in accordance with claim 33 wherein the optical switch circuit is further configured to selectively provide the electrical power to the another external load during a provision of the electrical power from the external source to the irrigation controller.

39. An apparatus for controlling irrigation, comprising:

a sensor including a pair of spaced insulated conductors, the pair of spaced insulated conductors supported in a fill material within a water-permeable shell, the sensor configured to provide an electrical capacitance corresponding to detected moisture which is indicative of ambient moisture concentration about the water-permeable shell;

an ancillary circuit electrically coupled to the sensor and configured to provide an electrical moisture signal corresponding to the electrical capacitance of the sensor; and

a controller electrically coupled to the ancillary circuit and configured to selectively provide a valve control signal responsive to a comparison of the electrical moisture signal and a selective threshold signal.

40. An apparatus according to claim 39 wherein the controller is further configured to energize the bridge circuit for a period of time and to ignore the electrical moisture signal for a portion of the period of time prior to the selectively providing the valve control signal.

41. An apparatus according to claim 39 wherein the controller is further configured to be electrically coupled to an external source of electrical power by way of an isolation transformer.

42. An apparatus according to claim 39 wherein the controller is further configured to energize the ancillary circuit and to perform the comparing and the selectively providing from time to time in correspondence to a provision of power from the external source.

43. An apparatus according to claim 39 and further comprising a plurality of sensors and a plurality of bridge circuits each electrically coupled to one of the plurality of sensors, the controller being electrically coupled to the plurality of bridge circuits and configured to selectively provide a plurality of valve control signals each responsive to a comparison of an electrical moisture signal from the corresponding bridge circuit and a corresponding selective threshold signal.

44. A method for controlling an irrigation system comprising:

installing a sensor including a pair of spaced helically wound insulated conductors supported in a sand fill within a zone to be irrigated;

coupling a bridge circuit to the sensor;

coupling a controller to the bridge circuit;

energizing the bridge circuit for a period of time using the controller;

exhibiting an electrical capacitance representative of a moisture concentration within the zone using the sensor;

developing an electrical moisture signal corresponding to the electrical capacitance for the period of time using the bridge circuit;

ignoring the electrical moisture signal for a portion of the period of time using the controller;

comparing the electrical moisture signal with a selective threshold signal using the controller; and

selectively providing a valve control signal to at least one valve within the zone responsive to the comparing using the controller.

45. A method according to claim 44 wherein the energizing and the exhibiting and the developing and the ignoring and the comparing and the selectively providing are performed from time to time responsive to a provision of electrical power from an external source.

46. A method of controlling an irrigation system having two zones, comprising:

providing electrical power for a watering period of time to a set of contacts on a controller using a time clock;

conducting electrical power to a bridge circuit coupled to a sensor for a sensing period of time defined by the controller;

sensing ground moisture concentration within a zone with the sensor and providing a corresponding moisture signal to the controller using the bridge circuit;

ignoring the moisture signal for a first portion of the sensing period of time using the controller;

comparing the moisture signal to a selectively adjustable threshold signal using the controller;

selectively energizing an external load associated with the zone for a later portion of the watering period of time responsive to the comparing, the later portion beginning after the sensing period of time has ended;

removing electrical power from the set of contacts on the controller after completion of the watering period of time using the time clock;

providing electrical power for a second watering period of time to a second set of contacts on the controller using the time clock, the second watering period beginning after completion of the watering period;

conducting electrical power to a second bridge circuit coupled to a second sensor for a second sensing period of time defined by the controller;

sensing ground moisture concentration within a second zone with the second sensor and providing a corresponding second moisture signal to the controller using the second bridge circuit;

ignoring the second moisture signal for a first portion of the second sensing period of time using the controller;

comparing the second moisture signal to a second selectively adjustable threshold signal using the controller;

selectively energizing a second external load for a later portion of the second watering period of time responsive to the comparing, the later portion of the second watering period beginning after the second sensing period of time has ended; and

removing electrical power from the second set of contacts on the controller upon completion of the second watering period of time using the time clock.